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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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MISSOURI - MUSSELSHELL BASIN
HARLOWTON SEWAGE LAGOON
HARLOWTON, MONTANA
MT-1416

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PREPARED FOR:

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CITY OF HARLOWTON
(OWNER/OPERATOR)

PREPARED BY:
HOSKINS-WESTERN-SONDEREGGER, INC.

JANUARY 1981

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers and with representation from the owner and from the State of Montana Department of Natural Resources and Conservation, the Harlowton Sewage Lagoon embankment was inspected by Hoskins-Western-Sonderegger, Inc., on 10 May 1979, under the authority of Public Law 92-367. The Harlowton Sewage Lagoon is located in Wheatland County, Montana, approximately one-half mile east of Harlowton.

This report was compiled from information obtained during an on-site inspection, a review of construction plans, and an analysis of hydrologic and hydraulic data. Findings were compared to engineering criteria currently accepted by most private and public agencies engaged in dam design, construction, and operation.

PRINCIPAL FINDINGS AND EVALUATIONS

The Harlowton Sewage Lagoon is a single-purpose project which consists of an embankment forming the north, east, and south sides of the roughly trapezoidal lagoon, with natural ground forming the west side. The lagoon has a surface area of about 19.7 acres and storage of about 129 acre-feet at the normal pool elevation (riser crest). The contributing drainage area includes only the lagoon and the crest of the embankment. The total drainage area, including the lagoon, is 21.2 acres.

In accordance with the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), the 10.6-foot-high Harlowton Sewage Lagoon embankment (MT-1416) is classified as being of small size and as having a significant (Category 2) downstream hazard potential, due to the possibility of dam failure resulting in damage to a residence, a secondary road, an irrigation canal, and the main line of the Chicago, Milwaukee, St. Paul and Pacific Railroad. Economic loss could result, especially when the environmental impact of a flood of partially-treated sewage is considered.

Inspection criteria (Ref. 1) recommend that the spillway design flood (SDF) for a small-sized project with a significant downstream hazard potential be in the rangeof the 100-year flood to 50 percent of the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. As an inhabitable structure would be endangered and economic losses may be realized due to failure of the embankment, we recommend that the project safely handle one-half of the PMF.

An estimated PMF was developed for the drainage basin during the dam safety analysis. This PMF, resulting from a 72-hour storm, has an estimated volume of 36 acre-feet for the Harlowton Sewage Lagoon. The PMF was assumed to begin with the reservoir at the riser crest elevation, 4183.0 feet. Approximately 60 acre-feet of storage is available between the riser crest elevation and the minimum embankment crest elevation. Reservoir routings of

the estimated PMF indicate that the Harlowton Sewage Lagoon will safely handle more than 100 percent of the PMF volume. On the basis of the field inspection and the study of hydrologic and operational data, the Harlowton Sewage Lagoon conforms to Corps guidelines with respect to discharge and/or storage capacities to safely handle the recommended SDF.

No seepage or evidence of seepage was found during the visual inspection of the embankment. No piezometers are installed to measure water levels in the embankments. An analysis of the evidence suggests that the embankment conforms to the recommended guidelines (Ref. 1) with respect to the stability of the upstream and downstream slopes.

PRINCIPAL RECOMMENDATIONS

Develop a downstream warning plan, for use in the event of possible dam failure and immediately place the plan in operation. Shrubs and bushes and their root systems must be removed from the embankment, and steps must be taken to prevent similar vegetative growth in the future. Erosion on the upstream slope of the embankment must be repaired, and adequate erosion protection should be installed. The outlet conduit must be inspected at a time when the lagoon level is lowered. Comprehensive inspections should be carried out at least once every 5 years.

Stephen H. Nickel
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal ID No.	MT-1416
Owner	City of Harlowton
Operator	City of Harlowton
Purpose	Sewage treatment
Location	1/2 mile East of Harlowton
Watershed	Musselshell River
Downstream Hazard Potential	Category 2 (Significant)
USGS Quadrangle	N.A.

2. RESERVOIR

Surface Area at Normal Pool	19.7 acres
Normal Storage (Riser Crest)	129 acre-feet
Total Storage (Min. Dam Crest)	190 acre-feet
Surcharge Storage	61 acre-feet
Drainage Area	21.2 acres

3. OUTLET STRUCTURE

Type	15-inch CMP riser, 15-inch CMP outlet conduit
Crest Elevation	4183.0 feet (NGVD)
Controls	Gate valve
Size	15-inch diameter valve, 15-inch-diameter conduit
Inlet Invert	4176.0 feet (NGVD)
Outlet Invert	4175.4 feet (NGVD)
Normal Tailwater	4175.4 feet (NGVD)
Discharge Capacity (Min. Dam Crest)	6.0 cfs

4. DAM

Type	Earth
Hydraulic Height	10.6 feet
Crest Length	4565 feet
Crest Elevation (Min.)	4186.0 feet (NGVD)
Crest Width	10 feet
Upstream Slope	1V to 4H
Downstream Slope	1V to 2H

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Harlowton Sewage Lagoon, owned by the City of Harlowton, Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Office of the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1) in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

The guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam;
(2) based upon an evaluation of the available data and a visual inspection;
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted; and
(4) not intended to include extensive explorations or analyses to provide detailed alternative correction recommendations.

The details of Phase I recommendations must be developed in a Phase II investigation. The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam and to develop the detailed correction recommendations. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulics and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer

serious questions relating to dam safety that cannot be answered otherwise. The Corps has no authority to enforce the recommendations contained in the safety reports. The responsibility for implementation of the Phase I recommendations or initiating the Phase II studies rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and neither any action nor failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project, review of construction drawings, and an interview with a representative of the owners. No stability analysis was available. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the inspection included:

Louis Boitano, Civil Engineer, Seattle District Corps of Engineers;
Lawrence Tegg, State of Montana, Department of Natural Resources and Conservation; and
Al Crawford, City of Harlowton, Montana.

Hoskins-Western-Sonderegger, Inc., personnel who participated in the field inspection and contributed to this report are:

Stephen Nickel, Geotechnical Engineer, Team Leader and
Richard Walker, Hydrologist/Hydraulics Engineer.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

The Harlowton Sewage Lagoon is an off-channel impoundment for the primary treatment of sewage from Harlowton. The lagoon is located in the flood plain of the Musselshell River. The lagoon is located in Section 26, T8N, R15E, in Wheatland County, Montana. The National Dam Inventory designates the lagoon embankment as MT-1416.

Wastewater enters the lagoon through a manhole on the west side of the impoundment. The outlet works consists of a concrete weir and a low-level slide gate. Discharge water enters a road ditch and eventually returns to the Musselshell River. There is no other spillway.

The lagoon has a normal surface area of 19.7 acres, with storage at the riser crest of 129 acre-feet. The contributing drainage area includes only the lagoon and the crest of the embankment. The total drainage area including the lagoon is about 21.2 acres.

The embankment is 10.6 feet high and impounds approximately 190 acre-feet at the minimum dam crest elevation. Based on a visual reconnaissance and engineering judgment, a residential home, a secondary road and the main line of the Chicago, Milwaukee, St. Paul and Pacific Railroad could be affected by a sudden breach of the dam. Economic loss resulting from a failure of the embankment could be excessive, especially when considering the environmental impact of a flood of partially-treated sewage. On the basis of this information and in accordance with the Recommended Guidelines (Ref. 1), the project is classified as small in size, and the downstream hazard potential is significant.

1.2.2 Regional Geology

The drainage area of the Musselshell River is a region of basin and range complicated by thrust faulting. Geographically, the Big Snowy Mountains and the Little Belt Mountains are on the north, the Crazy Mountains are on the south, the Castle Mountains are in the middle, and the Big Belt Mountains are on the west, forming a semicircle of mountains around a group of basins extending generally eastward onto the great plains.

Before the late Cretaceous, this was an area of quiet basinal sedimentation. Pre-Cambrian, Paleozoic, and Mesozoic sedimentation produced sandstones and shales. These Pre-Cambrian and Lower and Middle Paleozoic sedimentary and metamorphic rocks are exposed in the mountains and are only exposed due to the mountain-building that occurred here.

During this mountain-building phase, the basinal sediments were formed into a dome containing smaller anticlines and syclines. The most prominent of these are the Little Belt Mountains and the Snowy Mountains. Subsequent to the mountain building came erosion. Erosional debris from the mounatins swept down by rivers and streams covered the earlier Cretaceous sandstones and shales and formed the Eocene Fort Union formation, consisting of sandstone, shale, and bituminous coal.

Subsequent erosion of this domed basin has produced the present topography which shows a rim of Fort Union deposits with suceedingly older Cretaceous deposits toward the center of the present smaller basins. These Cretaceous deposits are predominantly the sandstones and shales of the Livingstone Formation. The oldest formation exposed in the basins is the Colorado Shale. Later Tertiary gravels and sand form the terraces and benches of the Musselshell River with Pleistocene alluvium along the recent bed of the river.

1.2.3 Seismicity

The Harlowton Sewage Lagoon lies in Seismic Zone 2 as indicated by the Seismic Zone Map (Ref. 1). The seismic probability of Zone 2 is one of a potential for moderate damage and is based on the known distribution of damaging earthquakes in the region.

No major faults have been mapped in the immediate vicinity of the Harlowton Sewage Lagoon although traces of minor faults can be inferred from aerial photographs and topographic maps. No active faults were found or inferred at the site of the dam. The closest fault identified on the Geologic Map of Montana lies 11 miles to the northwest.

Epicenters of local earthquakes significant enough to be reported in References 2 and 3 occur approximately along a line from 20 miles northwest of Helena to 25 miles north of Bozeman. The 3 largest reported earthquakes along this line have had intensities of VIII (modified Mercalli). One of these earthquakes had its epicenter at a point 25 miles north of Bozeman (27 June 1925), while the other two occurred at Helena (18 October and 31 October 1935). Of these 2 epicentral areas, the former is 66 miles and the latter 123 miles from the lagoon. No reported earthquakes have occurred at distances of less than 66 miles from the reservoir.

1.2.4 Site Geology

The Harlowton Sewage Lagoon lies in the flood plain of the Musselshell River. At the location of the lagoon, the Mussellshell River Valley is cut into the Claggett formation, which is primarily a shale with some snadstone. The valley fill is primarily sand and gravel. The thickness of the sand and gravel at the lagoon site is not known. About two feet of loamy soil overlaid the sand and gravel prior to construction of the lagoon. Much of this soil may have been used to form the embankment.

1.2.5 Design and Construction History

The lagoon was designed and built in 1958. The facility was designed by Wenzel and Company, Consulting Engineers, Great Falls, Montana. The plans show no description of the embankment material or of the site geology. Wenzel and Company is no longer in business, and no data, other than the construction plans, are available from the owner.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Outlet Structure

The outlet consists of a 15-inch-diameter corrugated metal pipe (CMP) riser and a 64-foot-long, 15-inch-diameter CMP outlet conduit through the embankment. The riser, which is located in a manhole in the middle of the embankment (Plate 3), has a crest elevation of 4183.0 feet. A 15-inch-diameter CMP leads from the lagoon to the manhole. A 15-inch gate valve, also located in the manhole, can be operated to lower the water surface elevation below 4183.0 and is normally opened temporarily in the fall of the year to allow for additional winter storage. As this valve is normally in the closed position, the assumption was made that it would remain closed during the entire PMP storm. The discharge rating curve for the 15-inch-diameter CMP, when the water surface elevation exceeds 4183.0, was computed and is shown on Plate 5. The discharge capacity of the outlet pipe at the minimum crest elevation of the embankment (4186.0 feet) was calculated to be 6 cfs. None of the inside of the conduit was inspected, as it was operating at the time of the inspection. There was some slight damage to the conduit at its outlet where it appeared to have been hit with a heavy object. However, it appeared that the damage would not affect the capacity of the outlet or the safety of the embankment.

2.1.2 Harlowton Sewage Inflow

Other than direct rainfall, the only other source of inflow for the lagoon is wastewater from the City of Harlowton. In accordance with accepted design practice for sewer usage, a flow of 150 gallons per capita per day (gpcd) was assumed. The population of Harlowton, 1375 people, when multiplied by 150 gpcd, results in a flow of 206,250 gallons per day into the lagoon. Assuming flow equalization over a 24-hour period, this is equivalent to a constant flow of 0.32 cubic feet per second (cfs).

2.1.3 Freeboard

The effective fetch for wind-generated waves is about 850 feet, and the wave run-up and wind set-up on the embankment is estimated to be about 14 inches (Ref. 4). A 3-foot difference exists between the minimum crest elevation of 4186.0 feet and the normal pool elevation of 4183.0 feet. This freeboard is considered adequate in preventing wave overtopping. The results of the routing indicate that the maximum water surface elevation during the PMF will be 4184.3 feet. The resulting 1.7 feet of freeboard is considered marginal in preventing wave overtopping during the PMF. At the time of inspection, the reservoir was at the normal operating level.

2.2 HYDROLOGY, CLIMATOLOGY AND PHYSIOGRAPHY

2.2.1 Physiography and Climatology

The climate of the area around Harlowton is highly variable, having great temperature extremes, and is most generally characterized as continental. The effects of foehn or chinook winds, which are westerly or southwesterly and Pacific Maritime in origin, are important in determining the extreme precipitation and runoff conditions which occur in this area. The summers are warm with cool nights and low humidity while winters are moderately cold and highly variable in severity.

Harlowton, located in the Musselshell River Valley at 4200 feet elevation, is the nearest climatological station. Precipitation data and climatological data are available for approximately 90 and 70 years, respectively. The mean annual precipitation at Harlowton is about 14 inches, and temperature extremes range from approximately -50°F. to 100°F. The average expected date of the last freeze is June 4th, and the average first freeze date is September 7th (Ref. 5).

The drainage basin is the reservoir itself and encompasses an area of approximately 21.2 acres. The normal pool elevation as indicated on the original plans (Plate 3) is 4183.0 feet, and the top of the embankment is at elevation 4186.0 feet.

2.2.2 Probable Maximum Flood

Inspection guidelines (Ref. 1) recommend that the spillway design flood (SDF) for a small-sized project with a significant downstream hazard potential be in the range of the 100-year flood to 50% of the Probable Maximum Flood (PMF). The Probable Maximum Flood is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

A Probable Maximum Precipitation (PMP) storm of 72-hour duration was applied to the reservoir. The 24-hour, 6-hour, and 1-hour PMP depths were estimated from the National Weather Technical Paper 38 (Ref. 6) to be 17.3, 14.0 and 8.5 inches, respectively. The 48-hour and 72-hour PMP depths were taken as 110 and 115 percent of the 24-hour value, respectively. All 6-hour increments from 0 to 72 hours, and the hourly increments of the maximum 6-hour interval, were arranged in a critical order of occurrence.

The PMF was assumed to result from a PMP storm in late spring, and, as the reservoir is the entire drainage basin, the conservative assumption was made that no losses occurred from either seepage or evaporation.

2.2.3 Reservoir Storage and Outlet Discharge

The reservoir has a surface area of about 19.7 acres and storage of about 129 acre-feet at the assumed outlet riser crest elevation of 4183.0 feet. Approximately 61 acre-feet of storage are available between this crest elevation and the minimum crest elevation of the embankment (4186.0 feet). The discharge from the outlet with the pool at the crest of the embankment is 6 cfs.

2.2.4 Flood Routing

A flood routing of the PMF was made to define the total volume of the PMF that could be handled by the reservoir before overtopping. The lagoon level at the beginning of the PMF was assumed to be at the normal pool elevation of 4183.0 feet, and the outlet control valve was assumed to be closed.

The total volume of the 72-hour PMF for the Harlowton Sewage Lagoon is approximately 36 acre-feet, with a peak inflow rate of approximately 330 cfs. The results of the routing show that the lagoon has the capacity to handle the entire PMF. Hydrograph computations and reservoir routings were done using the HEC-1 computer program (Ref. 7).

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam Embankment

The 10.6-foot-high embankment has a crest width of 10 feet and a crest length of about 4,565 feet. The embankment forms the north, east, and south sides of the roughly trapezoidal sewage lagoon, with both the right and left abutments near the west side of the lagoon. The upstream, or inside, slope is 1(V):4(H), and the downstream, or outside, slope is 1(V):2(H).

The soil exposed on the crest of the embankment appeared to be a mixture of silty clay and gravel. The location of the borrow source for this material is not known. This material is considered to be moderately erosive, and it is estimated that embankment failure will occur rapidly upon overtopping.

Riprap protection is provided only for the portion of the embankment forming the eastern side of the lagoon. The riprap is composed of relatively large pieces of broken concrete (see Photo 5). In addition, logs have been placed in the northeast and southeast corners of the lagoon, apparently also to act as riprap (see Photo 5). The remainder of the embankment is covered with grass. None of the slope coverings provide adequate protection against wave erosion, as there are concentrated erosion areas in the riprapped portion of the embankment and practically continuous erosion at the normal pool elevation along the remainder of the embankment (see Photo 4).

2.3.2 Foundation Conditions, Seepage, and Drainage

No boring logs were shown on the plans, and no other design or construction records are available. There is no record of any type of liner having been constructed. The area soil survey (Ref. 8) shows that the lagoon is located on about 1.5 to 2 feet of loamy soil overlying sand and gravel. The loamy soil can be considered to have been quite permeable at the time of construction, with permeability decreasing as sediment has accumulated. The permeability at this time is unknown. It was impossible to determine, by observation at the time of the inspection, the extent of seepage moving beneath the embankment and emerging at the downstream toe, as water was standing in the outlet channel along the toe of the embankment on the east side and in an irrigation ditch at the toe of the embankment along the south side. No seepage was observed to be moving through the embankment itself at the time of inspection.

There was no evidence to indicate that the embankment includes any type of drain. Nor is there any instrumentation, such as piezometers, installed in the dam.

2.3.3 Stability

A comparison of the upstream and downstream slopes of the Harlowton Sewage Lagoon embankment with the slopes of similar structures shows that these slopes are probably in conformance with the guidelines with respect to slope stability. No evidence of instability was noted during the inspection. Considering this information and the fact that the embankment is not more than 11 feet high and that it has performed satisfactorily for over 20 years, it is not necessary that a stability analysis be performed to determine actual safety factors.

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 Embankment

Operation and maintenance are the responsibility of the City of Harlowton. There is no formal plan for performing periodic maintenance on the embankment. At the time of the inspection, the most noticeable maintenance needs were the erosion in the riprap on the east side of the lagoon and the erosion at the normal pool elevation on the north and south sides of the lagoon (see Photos 4 and 5).

2.4.2 Reservoir

The water level in the lagoon is normally maintained at a constant level by the outlet riser. However, the outlet is used to lower the water surface level each fall to provide additional winter storage of sewage.

2.4.3 Warning System

There is no formal warning system or plan of action to warn persons downstream in the event of impending embankment failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the Harlowton Sewage Lagoon, supplemented by the analysis of the project in terms of the recommended guidelines' performance standards, resulted in the findings summarized in Sections 3.1.1. through 3.1.5.

3.1.1 Size, Hazard Classification and Safety Evaluation

In accordance with the recommended guidelines (Ref. 1), the Harlowton Sewage Lagoon is classified as small in size with a significant downstream hazard potential rating. The recommended spillway design flood (SDF) for this project (Ref. 1) is 50% of the Probable Maximum Flood (PMF). Because the project can safely handle the full PMF, it is in conformance with the guidelines' spillway design flood criteria.

3.1.2 Embankment

It is not possible to determine by observation whether significant seepage is actually occurring. Some seepage into underlying gravels can be implied from the site geology. However, there are no indications of slope instability or seepage problems.

Shrubs and bushes, primarily on the east portion of the embankment, may eventually pose a threat to the integrity of the embankment. If the root system of a perennial plant penetrates from one side of the embankment to the other, a channel is formed in which water can flow and quickly produce a piping failure.

The riprap along the eastern portion of the embankment and the grass on the upstream slopes of the north and south portions of the embankment do not provide adequate protection against wave erosion. There are concentrated erosion areas in the riprapped portion of the embankment, and there is practically continuous erosion along the remainder of the embankment at the normal pool elevation (see Photos 4 and 5).

3.1.3 Outlet Structure

The Harlowton Sewage Lagoon has one 15-inch-diameter CMP overflow pipe. This pipe has a 15-inch gate valve, which is operational, that allows the operators of the lagoon to lower the water level of the lagoon if additional storage capacity is needed. The outlet has a discharge capacity of 6 cfs at the crest of the embankment.

3.1.4 Reservoir Capacity

The flood resulting from a PMP storm of 72-hour duration for a 21.2-acre drainage area, the actual lagoon surface area, was computed to have a volume of approximately 36 acre-feet. The reservoir surcharge storage capacity is sufficient to handle 100% of the PMF.

3.1.5 Operation and Maintenance

Operation and maintenance are the responsibility of the City of Harlowton. There is no formal operation or maintenance plan. The pool elevation is lowered in the fall to provide additional winter storage. The most noticeable maintenance need at the time of the inspection was correction of erosion in the riprap on the east side of the lagoon and erosion at the normal pool elevation on the north and south sides of the lagoon (see Photos 4 and 5).

3.2 RECOMMENDATIONS

1. Immediately develop and implement and periodically test an emergency warning plan to alert persons and downstream interests in the event of imminent structural failure.

2. Remove all shrubs and brush and their root systems from the embankment, backfill and compact the resulting holes and take steps to prevent similar vegetative growth in the future.

3. Retain a qualified engineer to design an adequate riprap and filter material for protection on the upstream slopes. The engineer should also provide guidance on the repair of these areas.

4. Inspect the outlet conduit when the lagoon level is lowered. Make any necessary repairs.

5. Retain qualified engineers, with experience in dam design and construction, to perform a comprehensive inspection at least once every 5 years.

REFERENCES

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5. Caprio, J.M., "Montana: Average Dates of Freeze," Folders No. 81, 82, and 83, Montana Agricultural Experiment Station, Montana State College, Bozeman, Montana, March 1965.

6. U.S. Department of Commerce, Weather Bureau, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian, Technical Paper No. 38, U.S. Government Printing Office, Washington, D.C., 1960.

7. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Users' Manual for Dam Safety Investigations, Davis, California, September 1978.

8. Nunns, F. K., Soil Survey of the Upper Musselshell Valley Area, Montana. Montana Agricultural Experiment Station, U.S. Department of Agriculture, Series 1939, No. 1, November 1943.

(PHOTO 1) Overview, Harlowton Sewage Lagoon.

(PHOTO 2) Lagoon From Left Side of Valley, Downstream.

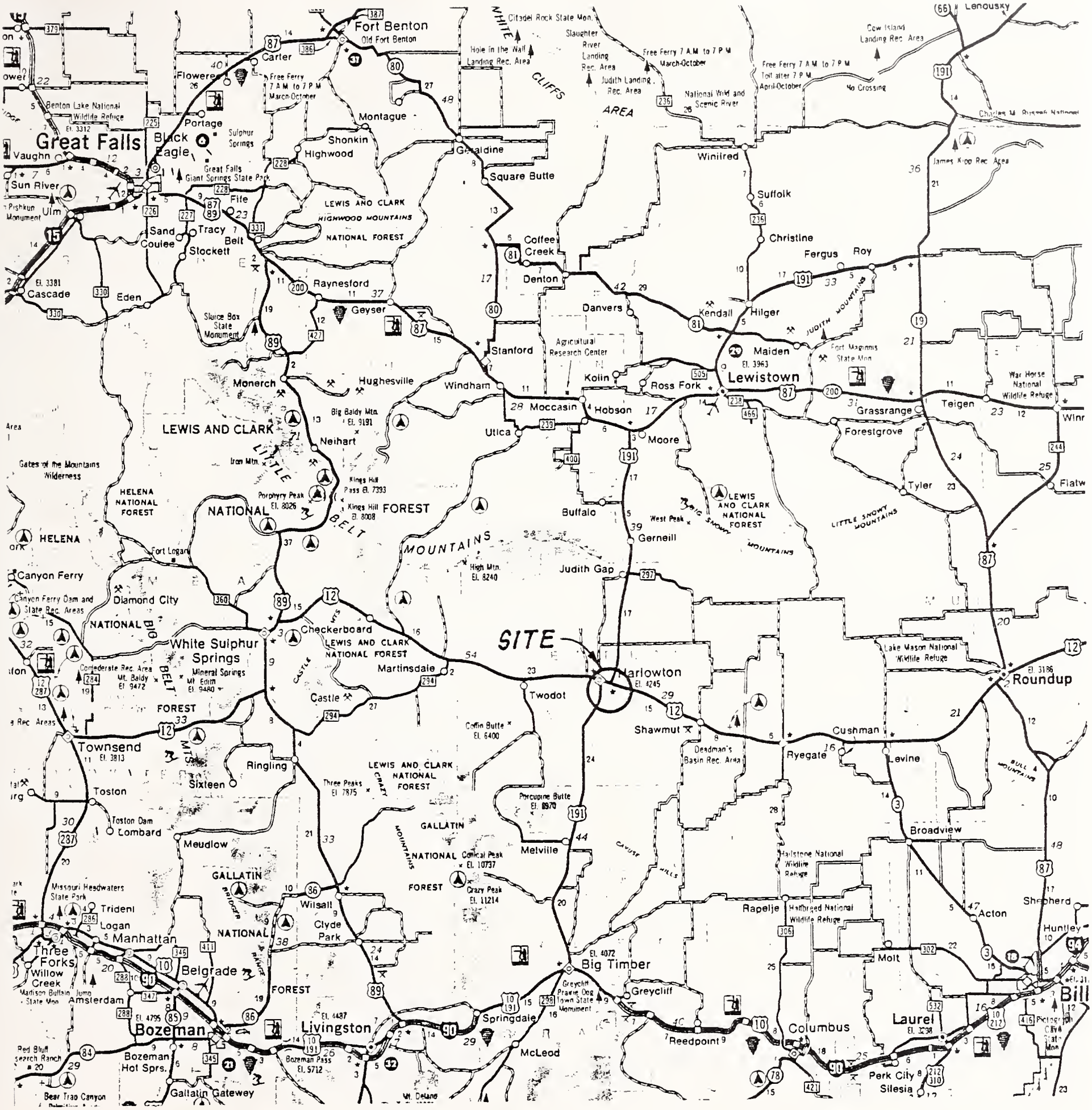
(PHOTO 3) Right Abutment, Embankment Crest, and Lagoon. Incoming Sewage Passes Through Manhole in Foreground.

(PHOTO 4) Left Abutment and Embankment Crest. This Photo Taken Approximately 600 Feet North of Photo 3.

(PHOTO 5) Upstream Face of Eastern Portion of Embankment Outlet is Through a Manhole Near Where the Man is Standing. Note Logs as Riprap.

(PHOTO 6) Conduit Outlet.

(PHOTO 7) Channel Downstream from Conduit Outlet.



VICINITY MAP

N

PLATE 1
HARLOWTON SEWAGE LAGOON

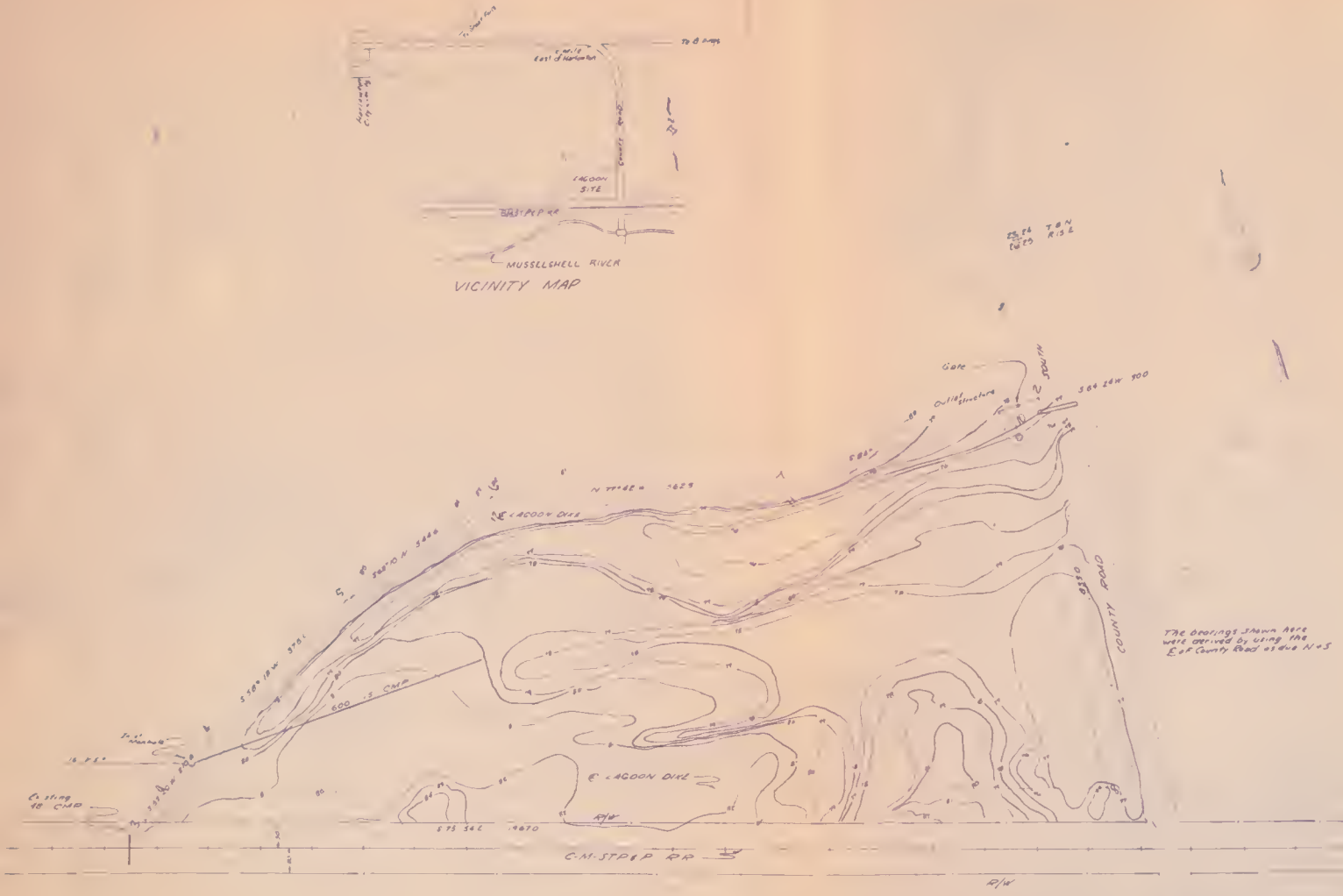
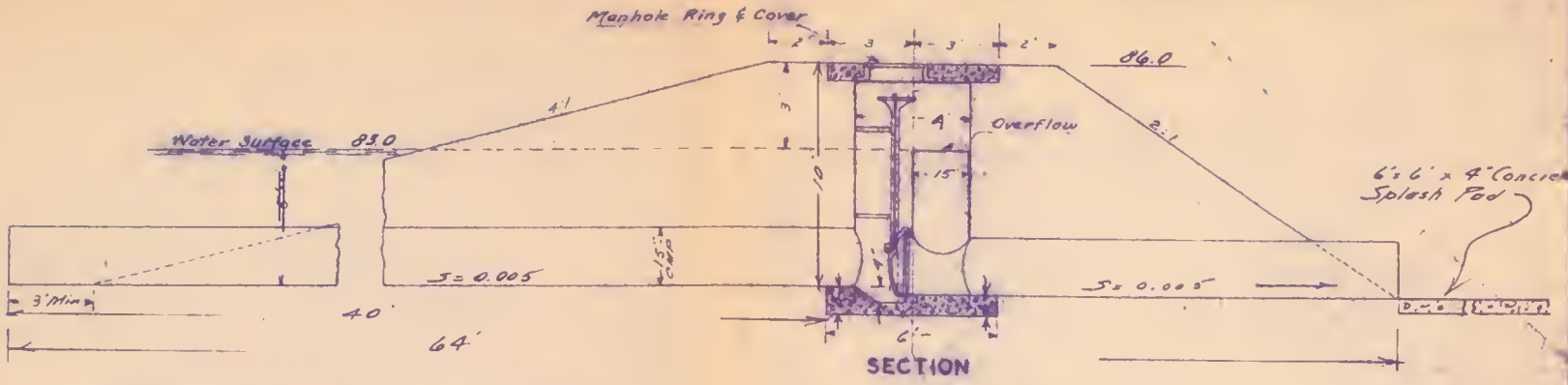
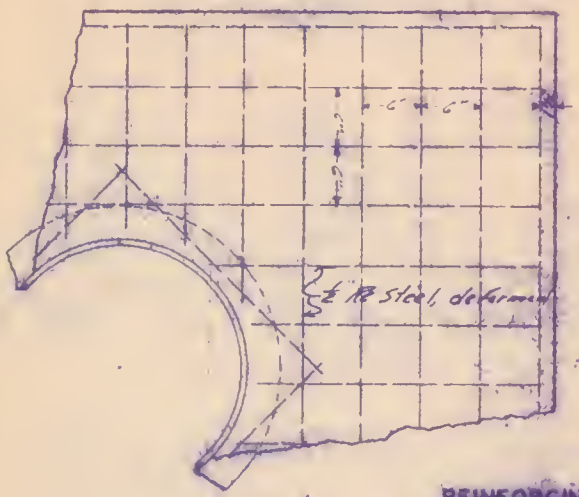


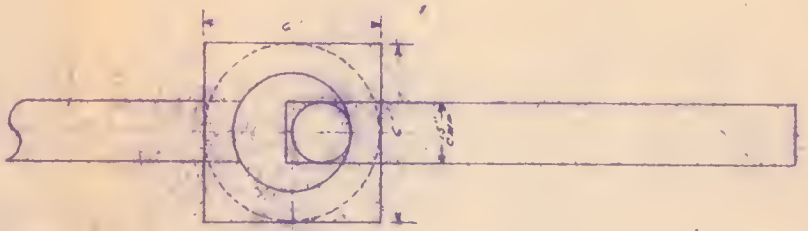
PLATE 2

SEWAGE TREATMENT LAGOON
LAGOON SITE
HARLOWTON, MONTANA



SECTION





PLAN

REINFORCING DETAILS

PLATE 3

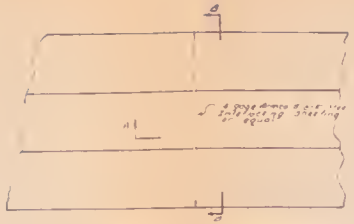
OUTLET STRUCTURE
SEWAGE DISPOSAL LAGOON
HARLOWTON, MONTANA

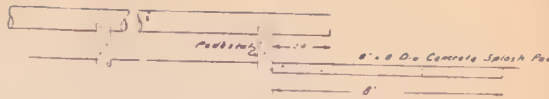
J.E.	M.N.S.	
Quan.	Inst. No.	
SCALE	As Shown	

WENGL & COMPANY
CONSULTING ENGINEERS
GREAT FALLS, MONTANA

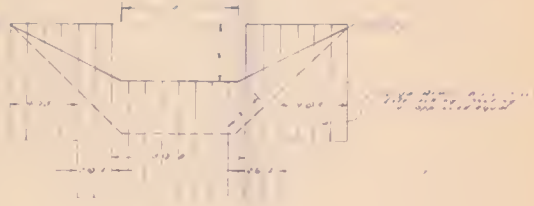
SHEET 5 of 5

May 20, 1958
25-57-5

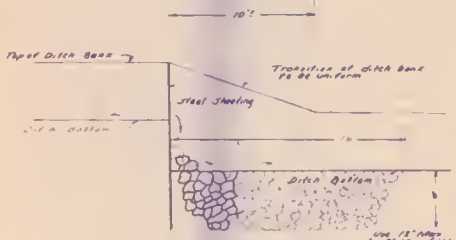




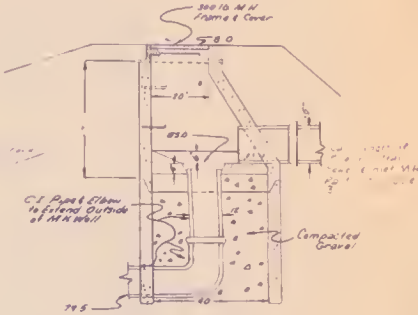
INLET PIPE SLIDE GATE
Scale 1/2"=1'



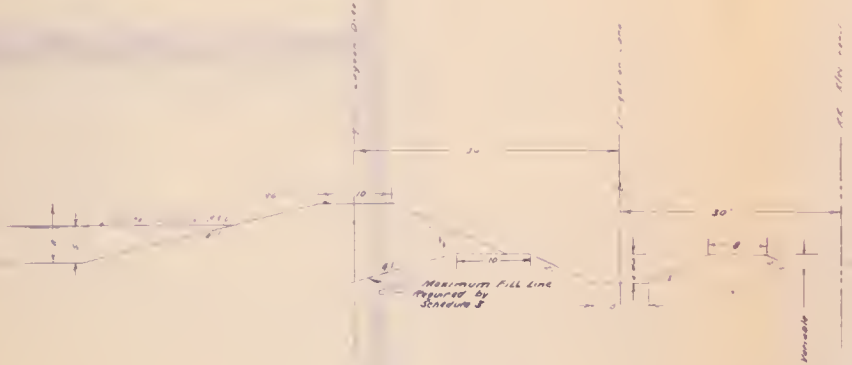
St. T SH. B B.
96" or Canal Drop Structure
Scale 1/2"=1'



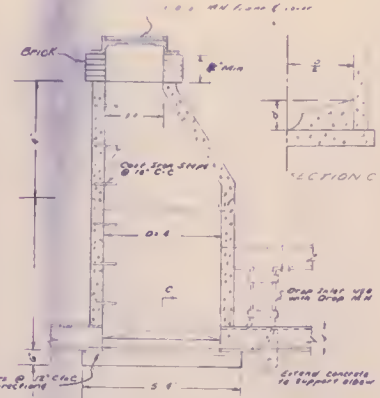
SECTION A-A
Irrigation Canal Drop Structure
Scale 1/2"=1'



SECTION
INLET MANHOLE



TYPICAL SECTION
Scale 1/2"=1'



SECTION PRECAST MANHOLE
with
ECCENTRIC REDUCER
Scale 1/2"=1'

CONCRETE PEDESTAL
One for each length of
Inlet Pipe
Scale 1"=1'

PLATE 4

CONSTRUCTION DETAILS
HARLOWTON, MONTANA

OUTLET STUCTURE OISCHARGE RATING CURVE
15-INCH OIAMETER C.M.P.-VALVE CLOSED

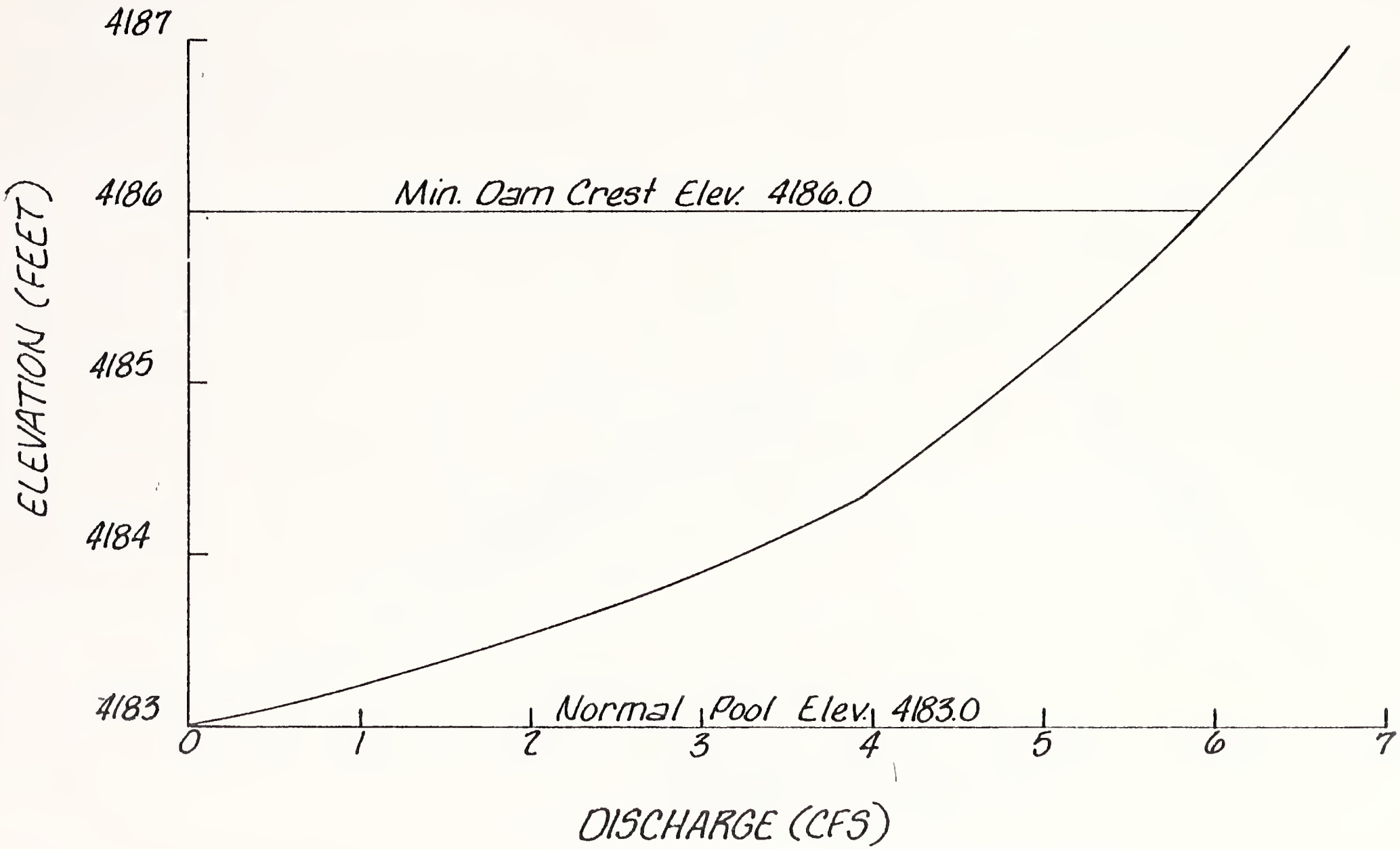


PLATE 5

STAGE - STORAGE CURVE
HARLOWTON SEWAGE LAGOON

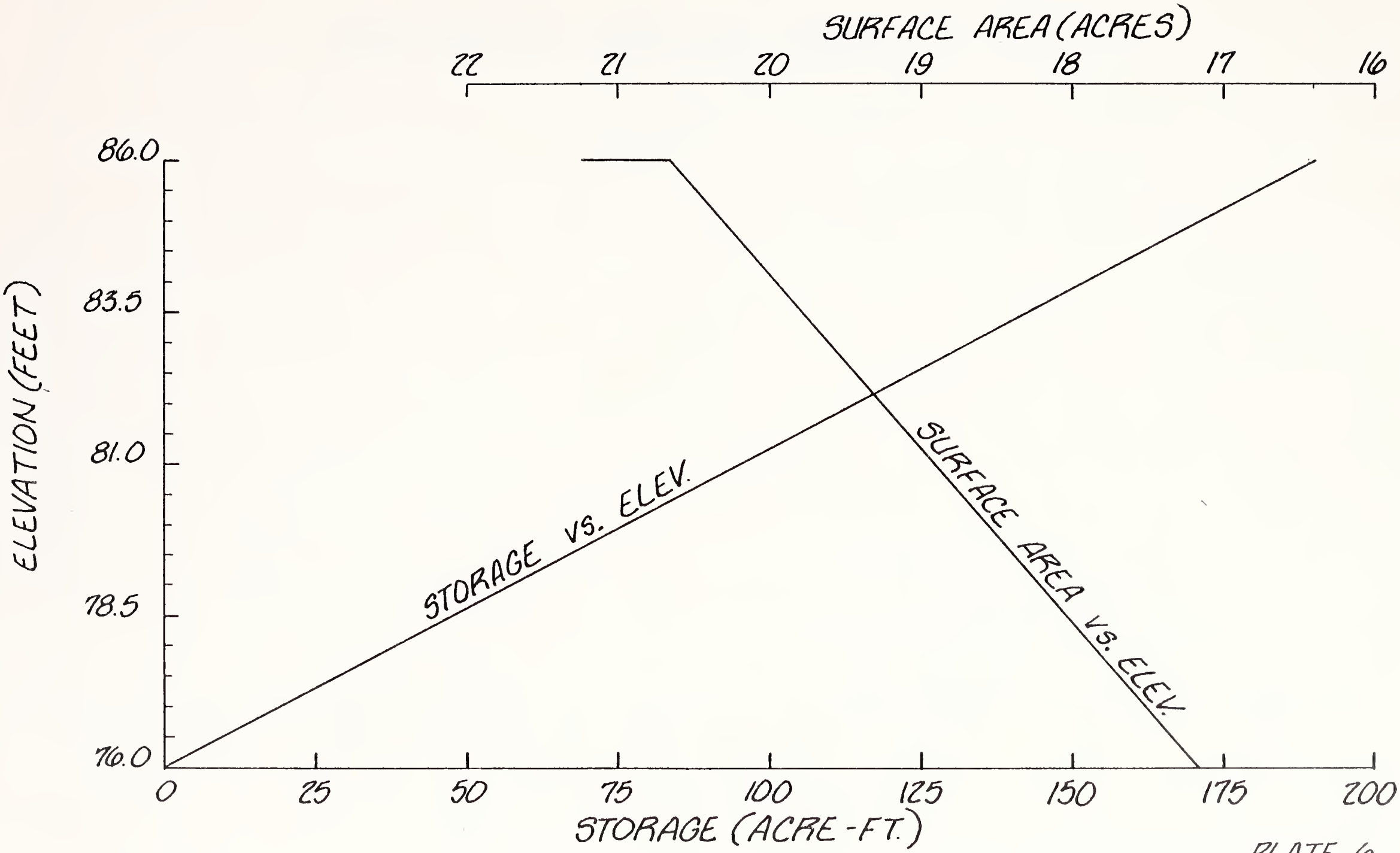


PLATE 6

HARLOWTON SEWAGE LAGOON

PMP DEPTH - DURATION CURVE

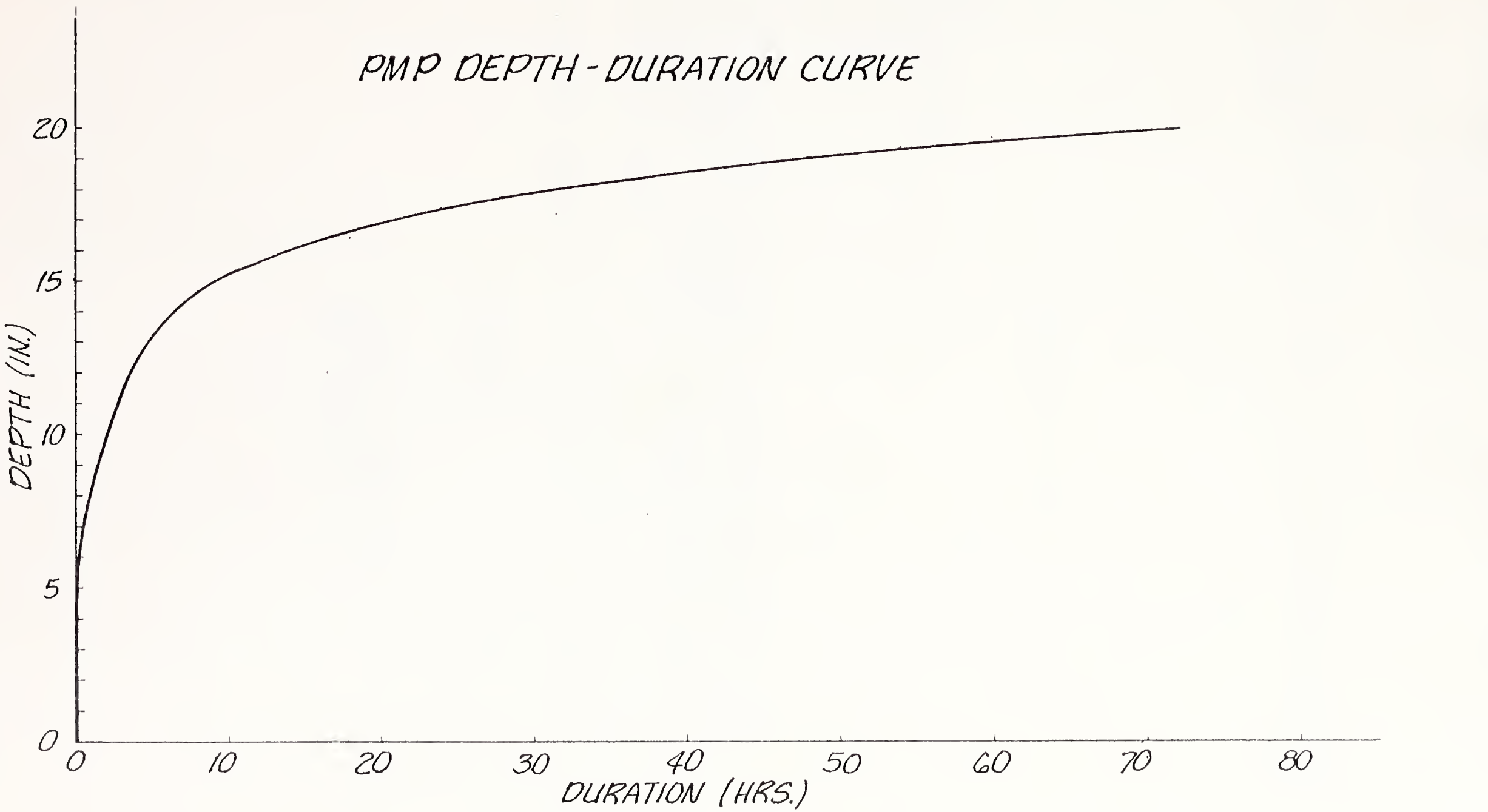


PLATE 7

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

September 3, 1980

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on the Harlowton Sewage Lagoon (MT-1416). We concur with the findings and recommendations and feel that the report satisfies the criteria for the Phase I evaluation. Minor comments have been discussed with your staff and we understand that these will be included in the final report.

Thank you for this opportunity to review and comment on the final draft report for this project.

Sincerely,

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/LT/lj

"AN EQUAL OPPORTUNITY EMPLOYER"